

REMARKS:

Claims 1, 3, 4, 6, 8 and 10-21 were pending in the application. By this amendment, claims 1, 4, 11, 12 and 21 are being amended, claim 3 is being cancelled, and new claims 22, 23, 24 and 25 are being added, to advance the prosecution of the application. No new matter is involved.

In the Final Office Action of May 21, 2002, claims 1, 3, 4, 6, 8 and 10-21 were rejected under 35 U.S.C. §103(a) as obvious in view of various combinations of the references to Hayashida, Suzuki, Kern, Gill and Ilardi. These rejections were discussed in a telephonic interview with the undersigned on June 3, 2002. The courtesy of the telephonic interview is gratefully acknowledged by applicant. This amendment is being made in view of such discussion.

In the Final Office Action of May 21, 2002, various independent claims including claims 1, 4 and 21 are rejected under 35 U.S.C. §103(a) as being unpatentable over Hayashida in view of Suzuki. Applicant is amending claims 1, 4 and 21 herein. As so amended, claims 1, 4 and 21 read as follows:

1. A storage water used for storage of a silicon wafer in water, wherein the storage water is ultra pure water containing Cu at a concentration of 0.01 ppb or less.

4. A method of a storing a silicon wafer in water, comprising the steps of preparing storage water, which is ultra pure water containing Cu at a concentration of 0.01 ppb or less, and storing a silicon wafer in the prepared storage water.

21. A regulating method of a storage water used for storage of a silicon wafer in water, wherein the concentration of Cu in the storage water, which is also pure water, is regulated to 0.01 ppb or less.

In each of these claims as amended, the storage water is defined as ultra pure water. As described at line 18 of page 19 of the specification, examples in accordance with the present invention utilize ultra pure water as the storage water. As further defined in the claims, the ultra pure water contains Cu at a

concentration of 0.01 ppb or less. Because silicon wafers are stored in the ultra pure water having an impurity concentration which is extremely low, contamination of the silicon wafers in the water storage can be prevented.

It is a feature of the present invention that the Cu concentration of the storage water is 0.01 ppb or less. Such a low concentration is unprecedented. As a result of analysis of the cause of degradation of the oxide dielectric breakdown voltage, in accordance with the invention, it was found for the first time that degradation of the breakdown voltage occurs even if silicon wafers are subjected to sufficient cleaning but a slight amount of Cu is present in the storage water used in the previous step of storage of the wafers in water. This is described at lines 11-27 of page 11 of the specification. Thus, it was recognized as a conceivable cause of contamination that when Cu exists in the storage water, it electrochemically reacts with Si to precipitate, so that defects are generated on the wafer. If defects are formed on the wafer in this manner, Cu which exists on the surface of the silicon wafer can be eliminated. However, defects cannot be eliminated even though cleaning such as SC-1 is performed. As a result, it was thought that degradation of the oxide dielectric breakdown voltage of an oxide film formed on the wafer is caused by the defects. Because of this, reduction of the Cu concentration in the storage water is deemed to be important for the countermeasure of degradation of the oxide dielectric breakdown voltage. Therefore, Cu concentration in the storage water is set at 0.01 ppb or less, as described at lines 1-6 of page 12 of the specification.

According to these features of the present invention, degradation of oxide dielectric breakdown voltage due to Cu contamination from the storage water can be prevented. This is described at lines 5-9 of page 10 of the specification.

The Examiner has previously stated that the recitation "Cu at a concentration of 0.01 ppb or less" in the claims would cover a Cu concentration of 0, and therefore Cu is not indispensable and the present invention can be read from Suzuki et al. even though such reference does not refer to Cu. In the interview of June 3, 2002, the Examiner stated that the claims are too broad because water

having a Cu concentration of 0.01 ppb or less would include most water. The Examiner has also stated that because Hayashida describes a cleaning solution having a Fe concentration of 0.01 ppb or less, which essentially relates to Cu concentration, and because Suzuki describes a method for storage of silicon wafers in water, therefore the present invention is obvious over Hayashida in view of Suzuki.

However, statements that the storage water in accordance with the present invention would include most waters indicates a misunderstanding. The essential feature of the present invention is the use of "ultra pure water". Ultra pure water is generally defined as water having a resistivity of $10\text{M}\Omega\cdot\text{cm}$ or more, an electric conductivity of $0.1\ \mu\text{s}/\text{cm}$ or less and dissolved solids of 50 ppb or less. As compared to normal water, the ultra pure water is controlled to be highly purified water. On the contrary, common drinking water has a resistivity of $0.01\text{-}0.005\text{M}\Omega\cdot\text{cm}$, an electric conductivity of $100\text{-}200\ \mu\text{s}/\text{cm}$ and dissolved solids of approximately 50,000-100,000 ppb. Also, "purified water", which is more purified than normal water, is generally defined as water having a resistivity of $1\text{M}\Omega\cdot\text{cm}$ or more, an electroconductivity of $1\ \mu\text{s}/\text{cm}$ or less and dissolved solids of 500 ppb or less. However, as compared to ultra pure water, the purity of purified water is very low. Therefore, because the essential feature of storage water in accordance with the present invention is that ultra pure water is used for the storage water, most water can be excluded.

Moreover, in accordance with a feature of the invention, the Cu concentration, which is the principal factor responsible for degradation of oxide dielectric breakdown voltage, in storage water is 0.01 ppb, which is an extremely low concentration. The Examiner has stated that because the lower limit of the Cu concentration is not defined, then the range of the Cu concentration as claimed is 0.01-0 ppb, and water having a Cu concentration of 0 ppb would be included in such range according to the invention so that Cu concentration cannot be regarded as the essential feature of the present invention. However, in reality, an impurity

concentration of 0 is in fact impossible. For example, the Cu concentration of drinking water is about 100-200 ppb and that of purified water is about 1 ppb. And even ultra pure water has a Cu concentration of about 0.1 ppb. However, the present invention employees water of extremely high purity having a Cu concentration of 0.01 ppb or less. Such water does not naturally exist. It cannot be produced without using ion exchange equipment, water purifying apparatus using a reverse osmosis membrane, or the like. Because storage water in accordance with the invention and as defined by the claims is not a common or naturally occurring form of water, the claims which define such storage water in accordance with the invention are not too broad.

The Hayashida reference describes a SC-1 cleaning solution using ultra pure water having Fe concentration of 0.01 ppb or less. However, the reference does not describe ultra pure water having a Cu concentration of 0.01 ppb or less. The Examiner has stated that a SC-1 cleaning solution having an Fe concentration of 0.01 ppb or less essentially relates to water having a Cu concentration of 0.01ppb or less. However, Hayashida states that the element, which damages electrical properties in connection with the SC-1 treatment is Fe (see lines 29-31 of column 2 of the reference). In other words, Hayashida primarily manages Fe concentration. It is clear from the description at lines 35-37 of column 4 thereof that "lowering of electric properties by the prior art is caused mainly by Fe". Moreover, as made clear by the description at lines 25-28 of column 2 of Hayashida "contamination with these metals in such concentrations except for Fe gives negligible influence of electrical properties such as oxide breakdown characteristics and recombination lifetime properties". Thus, the reference does not recognize that even if there is a slight amount of Cu in the water, the Cu causes degradation of the oxide dielectric breakdown voltage characteristics. Consequently, one of ordinary skill in the art could not conceive of storage in ultra pure water having a Cu concentration of 0.01 ppb or less, from the Hayashida reference and its concern with Fe concentration. The influence of Cu contamination on oxide dielectric breakdown voltage characteristics is neither shown nor suggested by the reference.

Moreover, Hayashida describes a cleaning method for effectively cleaning a silicon wafer so as to prevent degradation of the oxide dielectric breakdown voltage. Such reference neither describes nor suggests that Cu contamination causes degradation of the oxide dielectric breakdown voltage in the previous water storage step. As previously noted, the present inventors have found for the first time from their research that Cu contamination causes degradation of the oxide dielectric breakdown voltage. Consequently, when one of ordinary skill in the art is provided with the teaching of Hayashida, it would be determined that degradation of oxide dielectric breakdown voltage can be prevented by a cleaning step after the step of storage wafers in the storage water. Such teaching would not suggest the ultra pure water having a Cu concentration of 0.01 ppb or less in the manner of the present invention and as applied to the previous water storage step.

Suzuki describes storage of silicon wafers in an aqueous hydrogen peroxide solution. In this connection, the Examiner has asserted that because the Cu concentration of storage water in accordance with the present invention is regarded as 0-0.01 ppb, that water having a Cu concentration of 0 ppb is included in the range of the present invention, and therefore the present invention can be derived from Suzuki which has no description of Cu concentration. However, Suzuki describes storage water made of purified water whereby adding an aqueous hydrogen peroxide solution to purified water, as described at lines 30-34 of column 5 of the reference. As previously mentioned, because the impurity concentration of purified water is 500 ppb or less as a dissolved solid and the impurity concentration of ultra pure water in accordance with the present invention is 50 ppb or less as dissolved solids, such concentrations are completely different from each other.

The Examiner has further asserted that because Suzuki does not describe Cu concentration, that therefore the Cu concentration is regarded as 0 ppb. However, because Suzuki has no description of Cu concentration, the impurity concentration of purified water is approximately 500 ppb, and therefore, purified water must have a Cu concentration of about 1 ppb. Therefore, it is naturally predictable that the storage water of Suzuki has a Cu concentration of about 1 ppb, and accordingly, it is

a misinterpretation that Suzuki has storage water with a Cu concentration of 0 ppb. As previously described, Suzuki uses storage water having a purity which is much lower than that of the present invention. In other words, Suzuki uses water having a Cu concentration which is much higher than the storage water of the present invention. Therefore, Suzuki describes water which is clearly outside of the range of the present invention, and Suzuki would not suggest the present invention to one of ordinary skill in the art.

Furthermore, because the essential feature of Suzuki is to store wafers in an aqueous hydrogen peroxide solution, as described at lines 14-26 of column 3 thereof, such reference neither describes nor suggests that the purity of the storage water is increased. Inherently, the object of contamination control in Suzuki relates to a residual etching solution in a pre-step as described at lines 18-35 of column 2 of the reference but not for Cu ions.

This is because an etching solution remaining on the wafers is dissolved in an aqueous hydrogen peroxide solution and dispersed to extremely small concentrations. At the same time, the etching action of the chemical liquids exerted on the wafer surfaces is obstructed by the hydrogen peroxide that Suzuki adds to the storage water, as described at line 61 of column 3 through line 7 of column 4 of such reference. Accordingly, the object of contamination control in Suzuki does not relate to metals, and such reference neither describes nor suggests contamination due to Cu in particular. Consequently, from Suzuki's teaching, one of ordinary skill in the art could never derive the storage water in accordance with the present invention, which is ultra pure water having a Cu concentration of 0.01 ppb or less.

Regarding the rejection of the claims on the combination of Hayashida and Suzuki, it was previously mentioned that Hayashida inherently describes a cleaning step after a water storage step, and assumes that impurities causing degradation of oxide dielectric breakdown voltage can be eliminated by the cleaning step. It would not be possible for one skilled in the art to go from such teaching to the special water used in accordance with the present invention. On the other hand, the essential feature of Suzuki is to store wafers in an aqueous hydrogen peroxide

solution, and silicon wafers are not stored in water as they are, as described at lines 14-26 of column 3 of Suzuki. Furthermore, and as previously mentioned, the storage water of Suzuki is not used for preventing heavy metal contamination such as by Cu or Fe.

Therefore, there would be no motivation for one skilled in the art to combine Hayashida and Suzuki. Hayashida describes only a decrease of Fe concentration, and neither describes nor suggests decreasing Cu concentrations. Suzuki only describes that wafers are stored in low purified water having a purity which is much lower than that according to the present invention, or an aqueous hydrogen peroxide solution. Therefore, even if there were a basis for combining both such references, one of ordinary skill in the art could not derive the present invention therefrom.

Thus, the present invention has the effect, which is not suggested and cannot be expected from the two references, that degradation of oxide dielectric breakdown voltage due to Cu contamination from storage water can be prevented. This is described at lines 5-9 of page 10 of the specification.

As amended herein, claim 1 defines storage water for a silicon wafer which "is ultra pure water containing Cu at a concentration of 0.01 ppb or less". Claim 4 as amended similarly defines a method of storing a silicon wafer in water in which storage water is prepared "which is ultra pure water containing Cu at a concentration of 0.01 ppb or less". Similarly, claim 21 as amended defines a regulating method "wherein the concentration of Cu in the storage water, which is ultra pure water, is regulated to 0.01ppb or less". Thus, claims 1, 4 and 21 are submitted to clearly distinguish patentably over the prior art for the reasons discussed above.

Claim 3 is being cancelled herein. Claims 6 and 8 depend from claim 4, while claim 10 depends from claim 6. Such claims contain all of the limitations of claim 4 and are submitted to distinguish patentably over the art. Similar comments apply to claim 12 which is being amended to depend from claim 4, as well as claims 13-20 which depend, directly or indirectly, therefrom.

New claims 22, 23, 24 and 25 are similar to original claims 2, 5, 7 and 9, respectively, which claims were previously cancelled. As such, claims 22 and 23 depend respectively from and contain all of the limitations of claims 1 and 4. Claims 24 and 25 depend from and contain all of the limitations of claim 23. Therefore, such claims are also submitted to clearly distinguish patentably over the art.

In conclusion, claims 1, 4, 6, 8 and 10-21 and new claims 22-25, are submitted to clearly distinguish patentably over the prior art. Therefore, reexamination and allowance of such claims is respectively requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California telephone number (213) 337-6700 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,

HOGAN & HARTSON L.L.P.

Date: [MONTH #, #####]

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Version with markings to show changes made:

Rewrite claim 1 as follows:

1. (Three Times Amended) A storage water used for storage of a silicon wafer in water, wherein the storage water [contains]is ultra pure water containing Cu at a concentration of 0.01 ppb or less [and a surfactant].

Cancel claim 3, without prejudice.

Rewrite claim 4 as follows:

4. (Three Times Amended) A method of storing a silicon wafer in water, comprising the steps of preparing storage water, which is ultra pure water containing Cu at a concentration of 0.01 ppb or less [and a surfactant], and storing a silicon wafer in the prepared storage water.

Rewrite claim 11 as follows:

11. (Twice Amended) A method of storing a silicon wafer in water according to Claim [7]24, wherein the step of storing the silicon wafer comprises storing the silicon wafer immediately after polishing.

Rewrite claim 12 as follows:

12. (Twice Amended) A method of storing a silicon wafer in [a storage solution, comprising the steps]water according to claim 4, wherein the step of preparing storage water[or a chemical solution] includes using storage water containing a chelating agent[, and storing a silicon wafer in the prepared water or chemical solution].

Rewrite claim 21 as follows:

21. (Amended) A regulating method of a storage water used for storage of a silicon wafer in water, wherein the concentration of Cu in the storage water, which is ultra pure water, is regulated to 0.01 ppb or less.